CHAPTER-VII

SOILS

The exposed sediment successions in the valleys of the various north Gujarat rivers are intercalated with the various types of soils. Since they form part and parcel of the stratigraphy, provide an insight into the climatic factor, the author preferred to study them systematically for their detailed stratigraphy and textural mineralogical and chemical characteristics. Both surface and buried soils are reported from Sabarmati basin (Zeuner, 1950; Chamyal and Merh, 1992; Merh and Chamyal, 1993) and neighbouring areas (Pant and Chamyal, 1990). Soils of SW Rajasthan have also received a considerable attention.

The author selected quite a few soil profiles for detailed sampling for textural, clay mineralogical and chemical data which could inturn throw some light on paleoenvironmental conditions.

FIELD STUDIES

In the study area, two major and one insignificant surface soil types which evidently follow the geomorphic features are recognised. The insignificant surface soil has developed around Dharoi which geomorphologically forms an upland zone. The soil is dark brown to black, clay rich quite similar to the commonly known black cotton soil (Vertisol) of south Gujarat. These are clay rich having a typical Ah-Bc-Cck profile and show deep weathering measuring upto 0.8 to 1 m thick completely devoid of calcium carbonate. The surface shows development of polygonal cracks, a feature very distinctive of vertisols.

The two dominant surface soil profiles occur to the south of Dharoi are the brown forest type of soil that has very extensively formed all along the alluvial plains of the study area and has a typical Ah-Bt-Cca horizons. The other major surface soil has developed on dunes is a shallow granular Ah-Cca regosol type. The brown soil has a 0.5 to 0.6 m thick humus rich A horizon which grades down to 1 m thick clay rich horizon (Bt), the pedality is prismatic and it has a well developed Cca horizon of nodular carbonate. In the soil developed over the dunes (aridisol) the humus A-horizon directly grades down into a powdery granular calcium carbonate rich horizon.

In general, there are two well defined buried soils in the region, amongst the two, the red soil (rubified) is the most conspicuous by its colour and spatial spread. The soil has developed on fine sandy silt of fluvial origin and has a well developed carbonate crust at the base. The reddening is quite deep and shows secondary carbonate pellets varying in size from 1 mm to few cm, presence of this soil is a good indicator of late Pleistocene extreme climatic fluctuation (Pant and Chamyal, 1990). The other buried soil has developed on loess like material of Mahudi formation and is dark brown in colour and appears to be a Holocene soil. It is likely that this soil must have started forming immediately after its deposition during Terminal Pleistocene. The soil has developed a deeply weathered profile and perhaps represents a polygenetic pedocomplex. Conditions conducive for the development of such a soil are hot-humid climate, thick vegetal cover and a considerable length of time.

LABORATORY ANALYSIS

Three surface and two buried soil profiles in the valleys of north Gujarat were selected for systematic sampling (for soil profile locations please see Table 7.1). Mechanical sieving and particle size analyzer (SACP-2) were used to know the size distribution. Light microscope was used for mineral composition and the clays were scanned on XRD. The elemental analysis were carried out by ED XRF spectrometer at the laboratories of N.G.R.I., Hyderabad. Determination of pH exchangeable cations and organic matter were made as outlined in soil chemical analysis (Jackson, 1958). Calcimeter was used to determine the calcium carbonate

SOIL PROFILE	SOIL TYPES	GEOMORPHIC UNIT	DEPTH CM	SAND %	SILT %	CLAY %	MINERALS %		REMARKS
1. DHAROI (SURFACE SOIL)	VERTISOL	UPLAND	10-20 60-70 100-110 150-160	30.5 20.5 16.6 18.9	42.2 41.5 44.6 48.2	27.30 38.00 38.80 32.90	QUARTZ FELSPAR MICAS CARBONATE OPAQUE & CLAY MINERALS	35 10 25 05 25	The minerals are genrally fresh, $CaCO_3$ grains are rounded, others are angular to sub-angular
2. MAHUDI (SURFACE SOIL)	BROWN SOIL	ALLUVIAL PLAIN	15-20 35-45 60-70 90-100	22.6 22.8 24.5 27.2	58.2 49.5 47.4 53.2	20.50 26.40 29.20 20.00	QUARTZ FELSPAR MICAS CARBONATE OPAQUE & CLAY MINERALS	30 20 20 05 20	Sorting is poor, sub-rounded sand grains are abundant. Minerals are fresh.
3. DEESA (SURFACE SOIL)	ARDISOL	DUNES	15-20 85-90 120-130 160-170	30.8 28.2 26.6 25.7	60.1 65.2 70.1 71.2	9.10 6.60 3.30 3.10	QUARTZ FELSPAR MICAS CARBONATE OPAQUE & CLAY MINERALS	40 10 15 15 20	Rounded $CaCO_3$ grains, other are sub-angular to sub-rounded. Minerals are usually fresh.
4. MAHUDI (BURIED SOIL)	DARK BROWN SOIL	ALLUVIAL PLAIN	10-20 60-70 90-100	42.30 38.37 36.50	43.45 47.21 48.90	14.25 14.42 14.60	QUARTZ FELSPAR MICAS CARBONATE & OTHERS	20 10 10 35 25	Sorting is finer and better sorted. Minerals are not very fresh.
5. HIRPURA (BURIED SOIL)	RED SOIL	ALLUVIAL PLAIN	15-25 45-55 85-95 105-120 150-160 190-200 250-260	67.50 65.40 64.30 68.37 51.45 54.70 65.4	21.70 18.90 21.20 17.80 31.35 24.80 17.90	14.70 17.50 21.20 13.93 16.20 20.50 18.50	QUARTZ FELSPAR MICAS CARBONATE & OTHERS	25 15 20 30 10	$CaCO_3$ grains are rounded to sub-rounded. Sand is better sorted. Minerals are not fresh.

Table 7.1 : Textural and mineralogical data of soils.

content.

DATA INTERPRETATION

TEXTURAL

The various textural parameters and minerals present in the various size fractions of the surface and buried soil profiles are summarized in Table 7.1. Mineralogically the quartz and feldspars show a decrease in the buried soils, however the one in the surface soils are comparatively found to be fresh. A few primary calcite are also present. The soil profiles when analysed under XRD (two, each surface and buried soils) show presence of smectite, illite, kaolinite, and chlorite (Table 7.2). Smectite and illite dominate over others. It appears that they are partly formed during soil genesis otherwise they have to be products of the parent material. This is inferred as they do not show any variation in their percentage in the C-horizon when compared with the upper horizons. Bronger *et al.* (1991) have also suggested that there is no difference in the clay mineralogy of the surface and buried soils of the Mahi river basin. According to them the soils of Mahi river were formed under similar climatic regimes. Overall, not only the Brown Forest type of surface soil in the Sabarmati and Banas river basins are typologically similar but the buried soils are also similar to recent soils because their properties refer to the similar climatic conditions (Bronger *et al.*, 1991).

The red soil which is very widely distributed all over the river basins of north Gujarat appears to be insitu and has developed on fine sandy silt studded

PROFILE LOCATION	HORIZON	SMECTITE	ILLITE	KAOLINITE	CHLORITE	VERMI-CULITE
1 Mahudi (Surface soil)	Ah	65	20	5	6	4
	Bw	55	15	13	8	9
	Bt	58	18	16	6	4
	Cca	70	19	8	2	1
2. Deesa (Surface soil)	Ah	70	15	9	4	2
	Bw	65	25	10	0	0
	Bt	60	20	9	6	5
3. Mahudi (Buried soil)	Bw	71	18	5	4	2
	Bt	75	15	4	4	2
	Ck	65	21	6	4	3
4. Hirpura (Buried soil)	Bw	58	28	6	5	5
	Bt	55	32	4	5	4
	Ck	62	30	5	2	1

Table 7.1 : Clay mineralogical data of soils.

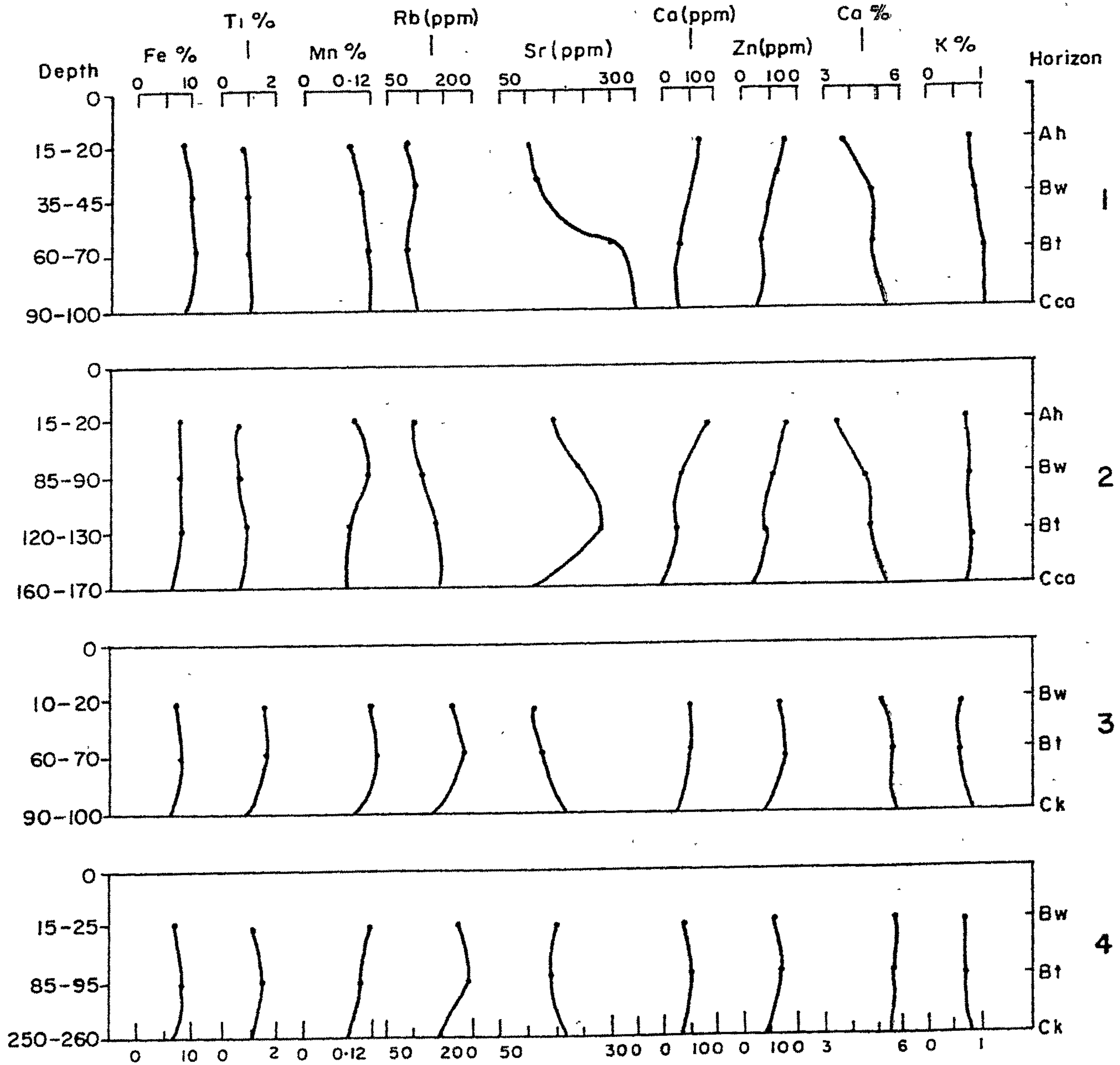
with secondary carbonate pellets of fluvial origin. The reddening is perhaps due to the presence of finely divided ferric form of iron. In the red beds of Sabarmati, it varies from 4 to 8 % and to impart bright red colours a very little percentage of ferric iron is sufficient (Pye, 1983). Among the clay minerals in the red beds, smectite and illite dominate. Kaolinite is also evident. The red beds in the Sabarmati and Banas river basins have developed mostly in areas of inactive geomorphic environments which are better drained. Perhaps, reddening has depended on climate, mineralogy of the parent material, texture, topography, vegetation and sediment stability (Pye, 1983).

The chemistry of the soils analysed (Table 7.3) show that the $CaCO_3$ is leached out of the A-horizon and is carried down the profile. B-horizon has enriched in Fe and $CaCO_3$, whereas the C-horizon indicates a further decrease in Fe, humus and $CaCO_3$. The soils are not completely decalcified. According to Wainwright (1964) the decalcification points to a calcareous nature of the parent material due to extremely arid conditions. The buried soil at Hirpura is red in colour but does not show higher values of FeO/Fe_2O_3 ratios. Whereas the surface soils and the dark brown buried soils show high FeO/Fe_2O_3 ratios, perhaps it is due to the continued weathering of iron bearing minerals. The major and trace elements are more revealing and the concentration values of Fe, Ti, Ca, Mn, K, Cu, Zn, Sr, and Rb were used. Fig 7.1 and Table 7.3 show their distribution in the various horizons of the surface and buried soils. The element distribution in the surface and buried soils indicate similar characteristics (Fig. 7.1). However, Cu and Zn are found more in the A-horizon of the surface soils probably due to plant activity and in the buried soil profiles Cu and Sr have leached further down in the

PROFILE LOCATION	HORIZON	DEPTH CM	ORGANIC CARBON	$CaCO_3$ %	EXCHANGEABLE CATION Ca^{++}	Mg^{++}	Na^{+}	K^{+}	pH	FeO/Fe_2O_3 %	FeO %	Ti %	Mn %	Rb ppm	Sr ppm	Cu ppm	Zn ppm
1. MAHUDI (Surface soil)	Ah	15-20	0.52	-	3.61	3.80	2.40	0.74	6.30	6.02	8.16	0.84	0.09	90	100	74	71
	Bw	35-45	0.15	-	4.80	3.75	2.45	0.76	7.22	4.10	8.29	0.87	0.10	95	130	56	58
	Bt	60-70	0.10	0.84	4.82	3.95	2.55	0.82	7.34	5.32	9.12	0.88	0.11	90	280	32	45
	Cca	90-100	0.09	1.13	5.20	3.82	2.64	0.86	7.42	6.44	8.86	0.90	0.11	100	295	29	35
2. DEESA (Surface soil)	Ah	15-20	0.32	-	3.42	3.75	2.60	0.75	7.11	7.05	8.12	0.70	0.10	95	150	84	80
	Bw	85-90	0.16	-	4.32	3.75	2.60	0.70	7.23	7.75	7.92	0.65	0.12	100	190	32	62
	Bt	120-130	0.09	-	4.95	3.65	2.65	0.92	7.45	6.95	7.85	0.88	0.09	110	240	25	47
	Cca	160-170	0.03	0.74	5.30	4.10	3.00	0.90	7.47	6.60	7.40	0.85	0.09	120	100	15	32
3. MAHUDI (Buried soil)	Bw	10-20	0.05	17.80	5.21	4.25	2.61	0.64	8.31	3.06	6.72	1.35	0.12	170	115	48	58
	Bt	60-70	0.03	17.92	5.60	4.20	2.72	0.66	8.72	4.45	7.30	1.31	0.12	185	130	42	62
	Ck	90-100	0.02	18.52	5.65	4.65	2.52	0.70	9.10	4.65	6.65	1.04	0.10	130	164	38	43
4. HIRPURA (Buried soil)	Bw	15-25	0.02	19.82	5.71	4.35	2.71	0.65	8.51	5.45	7.45	1.25	0.11	175	105	38	56
	Bt	85-95	0.01	20.92	5.65	4.40	2.82	0.64	8.35	6.75	7.85	1.42	0.09	195	90	47	60
	Ck	250-260	0.01	21.75	5.55	4.75	2.52	0.70	9.05	7.00	6.90	1.05	0.08	135	110	45	45

Table 7.3 : Chemical data of soils.

Fig. 7·1 VARIATION IN SELECTED ELEMENTS IN THE SOILS



1 = Mahudi (Surface soil) 2 = Deesa (Surface soil) 3 = Mahudi (Buried soil) 4 = Hirpura (Buried soil)

Cca horizon. The dominance of Fe, Ti, Rb, K and Mn and presence of Cu and Zn in the B-horizon of buried soils indicate that these elements are related to the process of soil formation (Lodha *et al.*, 1988).